2.2 Sampling Principles

Do radio call-in shows accurately reflect the opinions of all their listeners? Are these listeners likely to have the same opinions as people who do not listen to the program? How can you reduce the chances of inaccurate results from a survey?

Investigate

How can you choose participants for a survey?

A sportswear manufacturer is thinking of hiring a world-champion speed skater to help promote its products. Since the company wants someone who will appeal to teenagers, it surveyed 200 teenagers for their opinions about the speed skater.

1. Which of these **samples** is likely to accurately reflect the opinions of teenagers in the whole country? Explain.
   - **a)** 200 students at a school near the company's office
   - **b)** 200 teenagers selected from across Canada
   - **c)** the first 200 teenagers willing to answer a questionnaire at a shopping mall
   - **d)** 10 teenagers from each of 20 schools chosen from across Canada
2. **Reflect** How could you select a sample so that it properly represents the whole **population**?

sample
- any group of people or items selected from a population

population
- the whole group of people or items being studied

census
- a survey of all members of a population

The population depends on what you are trying to measure or study. If you are studying the music preferences of teenagers in your school, the population is all the teenagers in the school. It is often not practical to survey all members of a large population. So, instead of doing a **census**, you survey a sample of the population.

Example 1 Identify the Population

Identify the population in each situation. Then, indicate whether each researcher should survey a sample of the population or do a census. Explain your reasoning.

a) A teacher wishes to know how early his students wake up in the morning.

b) The principal of a school with 2100 students wants to find out how much homework her students have each day.

c) A clothing store needs to find out whether its customers are happy with its service.

d) A newspaper wants to know the public's opinion of a federal political party.

e) A polling firm wants to know how people will vote in the next federal election.

Solution

a) The population is the students in the teacher's class. He should do a census since the population is small and easy to survey.

b) The population is the students in the school. The principal should use a sample, since the school population is quite large and all students in any particular class may have the same amount of homework for that subject.

c) The population is the store's customers. A random sample is probably best because it could be difficult and time-consuming to reach all of the store's customers.

d) The population is everyone in Canada. The newspaper will have to use a sample since it is next to impossible to get the opinion of every person in Canada.

e) The population is every person who can vote in the next federal election. Again, a census is not practical. It will take far less time and expense to interview a sample of voters from across the country.

You can never be completely certain that a sample is representative of the population. However, a **random sample** usually gives reasonably accurate results. You can use several different methods to select a random sample.

random sample

- a sample in which all members of a population have an equal chance of being chosen

Example 2 Choose a Random Sample

A principal of a school with 1600 students wants to know whether they favour introducing school uniforms. Describe three methods he could use to select a random sample of 200 students.

Solution

1. The principal takes an alphabetical list of all the students at the school and numbers the names in sequence. He then uses a graphing calculator or a spreadsheet to generate 200 random numbers between 1 and 1600. He selects the names on the list that correspond to these numbers. This method is an example of **simple random sampling**.

2. The principal finds a starting point on the list of students by picking a single random number between 1 and 1600. To get a random sample with 200 students, he then selects every eighth name before and after the starting point. This method is an example of **systematic random sampling**.

3. The principal uses lists of the students in each grade. He then randomly selects the same fraction of students from the list for each grade. Since he wants a sample of 200 students out of a total of 1600, he needs to choose $\frac{200}{1600} = \frac{1}{8}$ of the students in each grade. Thus, if there are 480 students in grade 9, he would randomly select $\frac{1}{8} \times 480 = 60$ of these grade 9 students to be part of the sample. This method is an example of **stratified random sampling**.

simple random sampling

- choosing a specific number of members randomly from the entire population

systematic random sampling

- choosing members of a population at fixed intervals from a randomly selected member

stratified random sampling

- dividing a population into distinct groups and then choosing the same fraction of members from each group

non-random sampling

- using a method that is not random to choose a sample from a population

bias

- error resulting from choosing a sample that does not represent the whole population

Sometimes people use samples that are not randomly chosen. **Non-random sampling** can be cheaper or more convenient than random sampling, but the results are less likely to be accurate. Samples that are not random may tend to choose a certain type of member from the population. As a result of this **bias**, the sample does not properly represent the whole population.

Example 3 Identify Sampling Techniques

Identify the type of sampling in each situation. Explain any bias that the samples could have.

a) The personnel department sends questionnaires to 75 employees randomly selected from a list of everyone working for the company.

b) A computer randomly chooses one name from an alphabetical list of a store's customers and then also selects every 25th person listed before and after that name.

c) The president of a restaurant chain interviews employees at one branch.

d) The student council of a school randomly selects a number of students from each class. This number is proportional to the size of the class.

Solution

a) simple random sampling

b) systematic random sampling

c) non-random sampling: This sample could be biased since the employees of one branch may not be representative of the employees of the whole chain.

d) stratified random sampling

Key Concepts

- A population is the entire group of people or items that is being studied.
- A sample is any part of the population.
- A random sampling technique ensures that all members of a population are equally likely to be selected. As a result, a random sample is likely to be representative of the whole population.
- Sampling methods include simple random, systematic random, stratified random, and non-random sampling.
- Bias can make the results of a survey inaccurate.

Communicate Your Understanding

C1 The city council is considering building a new library. Your councillor surveys 75 people in your neighbourhood to see if they approve of this expense. Is this survey a good method for judging how the citizens of the city feel about the project? Use the words "population" and "sample" in your explanation.

C2 **a)** Describe two ways you could select a random sample to estimate how many of the students in your school have access to the Internet at home.

b) Describe a survey method that is unlikely to give an accurate estimate.

Practise

For help with questions 1 and 2, see Example 1.

1. Identify the population in each situation.

a) Generally, girls learn to walk before boys do.

b) The mean mark on yesterday's test was 72%.

c) As cars age, their repair costs increase.

d) Most food stores charge more for cream than for milk.

2. Describe the data required to answer each question. Explain whether you would use a census or a sample to collect each set of data.

a) Do girls learn to walk before boys do?

b) Is the mean mark on a test greater than 75%?

c) Is the mean annual salary of employees in Canada less than $50 000?

d) How are a person's height and age related?

e) What is the most common make of car in your school's parking lot?

f) What is the most common colour among the cars that drive by your school?

For help with question 3, see Example 2.

3. Describe how you could choose a random sample to determine each of the following.

a) the type of coffee preferred by customers of a local cafe

b) Ontario teenagers' favourite magazines

c) political parties supported by bilingual Canadians

d) countries of origin for immigrants to Canada

For help with question 4, see Example 3.

4. Identify the type of sample in each situation. Comment on any possible bias in these samples.

a) A career studies class interviews University of Waterloo graduates to learn about career choices for university graduates.

b) A town council randomly selects phone numbers from a town directory to survey citizens' opinions on a new park.

c) Moviegoers leaving a cinema are interviewed to find out how people spend their free time.

d) Every fifth person entering the cafeteria is asked to fill out a questionnaire about the menu.

Connect and Apply

5. List three ways you could divide the students in your school into groups for selecting a stratified random sample.

6. A government agency wants to survey Ontario farmers.

a) Identify the population.

b) Suggest a stratified random sampling technique that the agency could use.

7. A company wants to select 50 of its 325 employees for a survey.

a) Identify the population.

b) Describe a systematic random sampling technique that the company could use.

8. The physical education department wants to survey the members of school teams.

a) Identify the population.

b) Describe a method of randomly selecting 15% of the members of the teams.

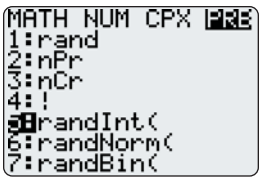
9. This table lists the enrolment at a high school.

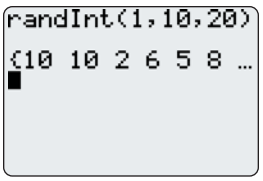
Grade	Number of Students
9	330
10	308
11	295
12	283

The school administration wants to interview a random sample of 150 students, stratified by grade. How many students should the administration select from each grade?

Did You Know?

Births in Canada peaked at 405 486 in 1990. As a result, total enrolment is high schools is now declining.





10. **Use Technology** Use this method to generate random integers with a TI-83 Plus or TI-84 graphing calculator.

- Press MATH. Cursor over to display the **PRB** menu.
- Move the cursor down to **5:randInt(**, and press ENTER.
- Press **1** , **10** , **20**) ENTER.

The calculator will display 20 randomly selected integers between 1 and 10, inclusive.

a) What command would you enter to produce a list of 25 random integers between 12 and 36?

b) How could you use a graphing calculator to randomly select 40 house numbers between 1 and 500?

c) What command would you enter to randomly select 75 house numbers between 100 and 1000?

11. A survey selects five students from each grade at 100 high schools across Ontario.

a) Explain why this sample is not completely random.

b) How does this sampling method bias the results of the survey?

12. Identify the population for each of the following. Then, describe how you could select an appropriate sample of each population.

a) the popularity of various kinds of music in your school

b) the popularity of various kinds of music in your community

c) the effectiveness of a national campaign to convince people between the ages of 18 and 30 not to smoke

d) the spending habits of senior citizens in Ontario

e) the quality of printing from various computer printers on sale in Canada

f) the mean cost of gasoline in your community

13. In a *voluntary sample*, people choose to answer the survey, rather than being selected by the person doing the survey. For example, a Web site could ask people browsing the site to fill out an online survey form. Discuss whether this voluntary sample accurately represents a population.

14. Even in the 1920s, polling companies conducted surveys by calling people randomly selected from telephone directories.

a) Explain why using this sampling method in the 1920s would not produce a representative sample of the opinions of everyone in the country.

b) Describe two ways in which a telephone survey today could be biased.

15. Design and conduct a survey to determine how much exercise students get. Present your results in a table and a graph. Explain your choice of sampling technique.

16. Design and conduct a survey to determine
- the percent of students in your school who buy lunch in the school's cafeteria
- the reasons for their choice

Present your data in a table and a bar graph. Explain your choice of sampling technique.

Extend

17. Bias can occur in a survey if it uses non-random sampling. Describe two other ways a survey can become biased.

18. To make sure that the Asian long-horned beetle is not infesting trees in a large downtown park, the city's forester decides to inspect 10% of the trees. Describe how the forester could choose which trees to inspect using

a) simple random sampling

b) stratified random sampling

c) systematic random sampling

d) non-random sampling

Which would be the best method to use? Explain your reasoning.

Did You Know?

The Asian long-horned beetle, *Anoplophora glabripennis* is called long-horned because it has two long antennae.

19. Survey companies often use *convenience samples* because they are easy to do. Interviewing shoppers at a mall is one example of a convenience sample.

a) Work with a partner to list two more examples of convenience samples.

b) Debate the statement "Convenience samples are true random samples." One partner argues for the statement, while the other argues against it. Debate for a maximum of 5 min. Then, decide if the statement is correct.

20. **Math Contest** How many odd three-digit numbers can be made by choosing from the digits 1, 2, 3, 4, 5, 6, and 7 if each number must contain three different digits?